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Sato

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(54) **IMAGE FORMING APPARATUS AND EXPOSING APPARATUS**

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(30) **Foreign Application Priority Data**

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G03G 15/043 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/043*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/043; G03G 15/5041
See application file for complete search history.

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(57) **ABSTRACT**

An image forming apparatus includes a light scan head having a plurality of LED elements disposed along a main-scanning direction of a photoreceptor drum and configured to expose the photoreceptor drum with light, a developing device disposed to face the photoreceptor drum in the main-scanning direction and including a development roller configured to supply a developer to the photoreceptor drum, and a non-uniform density correction unit configured to control an intensity of light emitted from the plurality of LED elements of the light scan head based on correction data that corresponds to a tendency pattern of an expected non-uniform image density so as to correct the non-uniform density of an image that is to be formed on a recording medium.

12 Claims, 9 Drawing Sheets

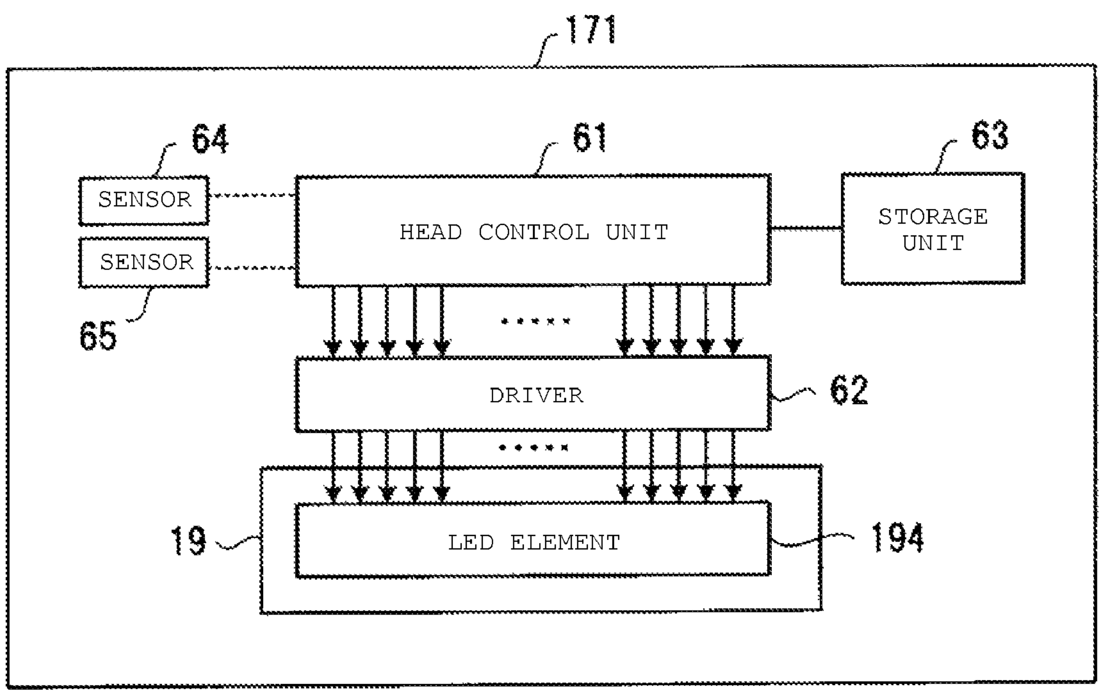
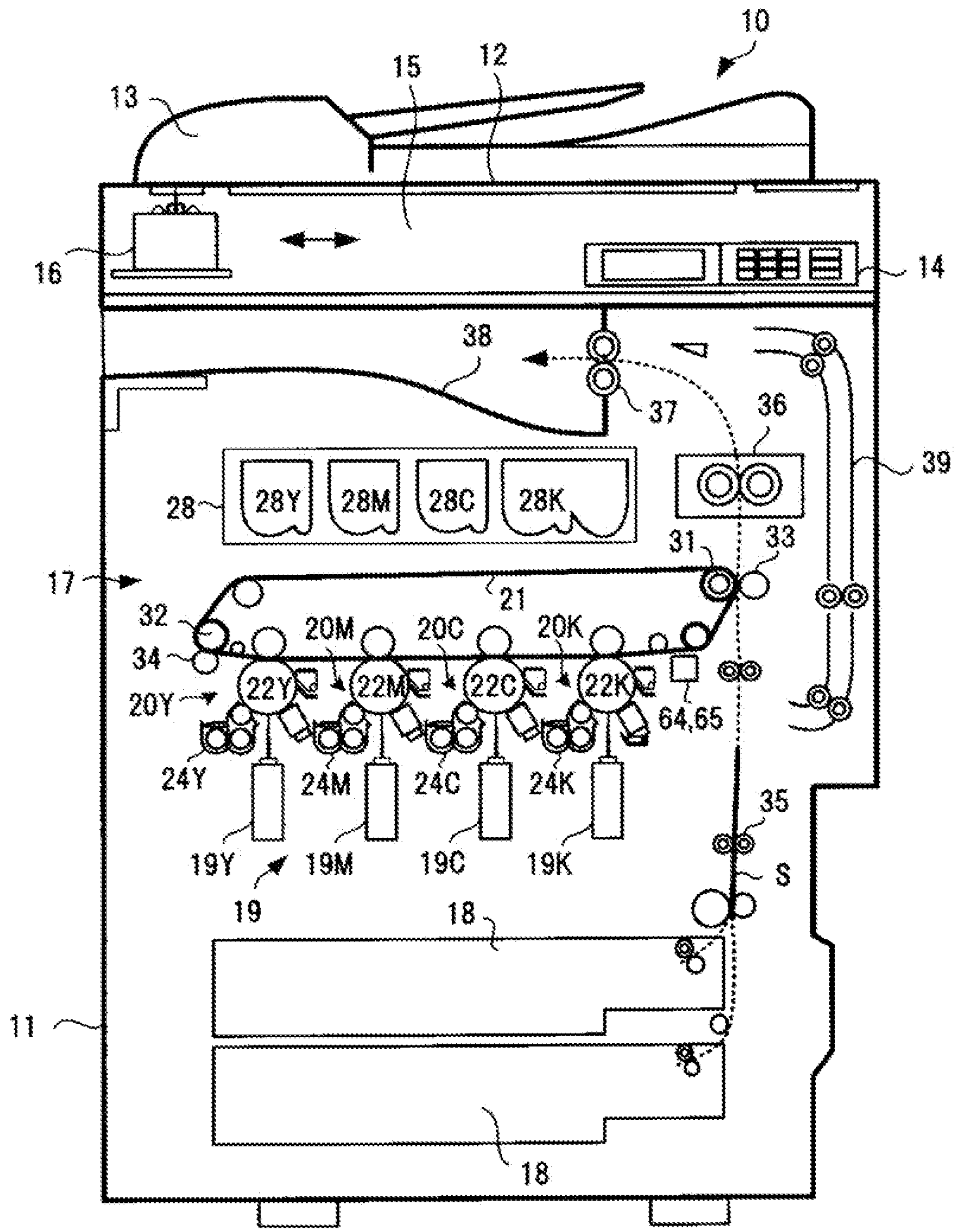


FIG. 1



10
15
12
13
16
14
38
37
36
39
28
28Y
28M
28C
28K
31
33
17
21
32
20M
20C
20K
34
22Y
22M
22C
22K
20Y
64,65
24Y
24M
24C
24K
35
19Y
19M
19C
19K
S
19
18
11
18

FIG. 2

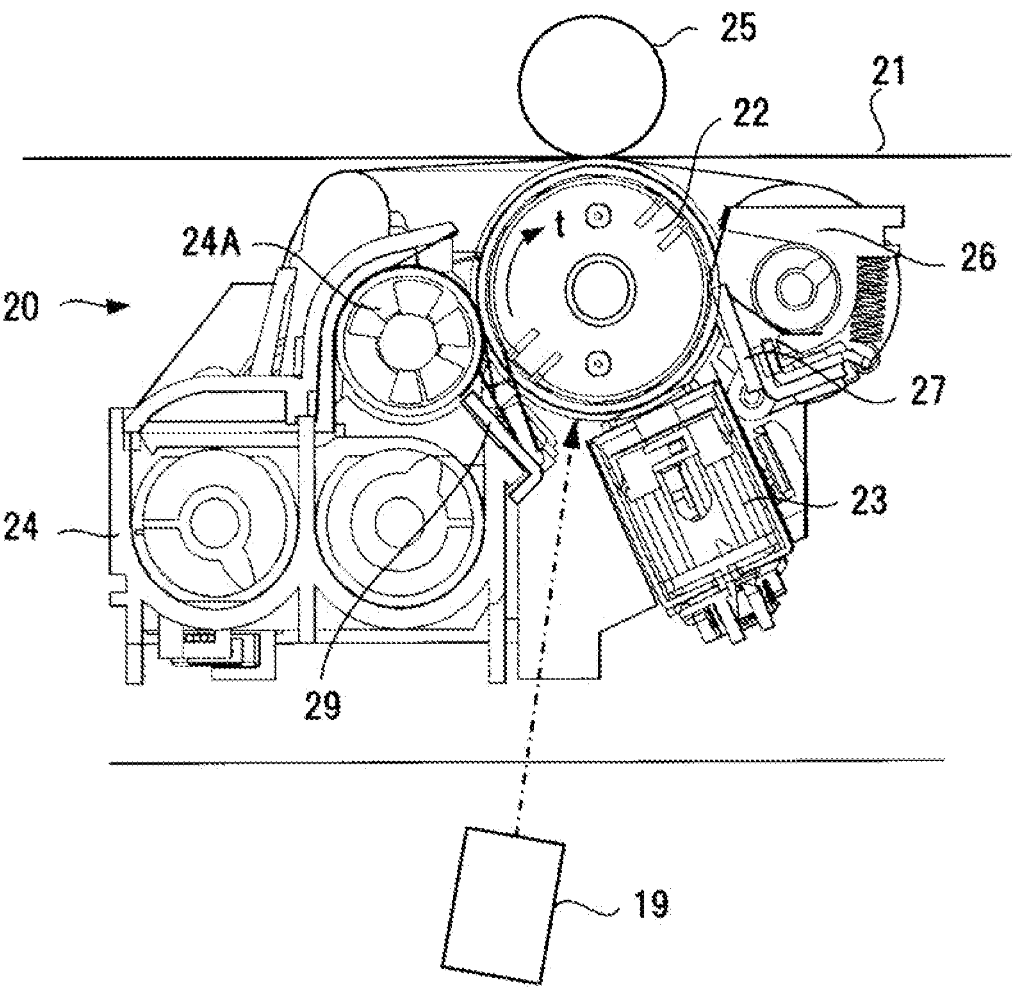


FIG. 3

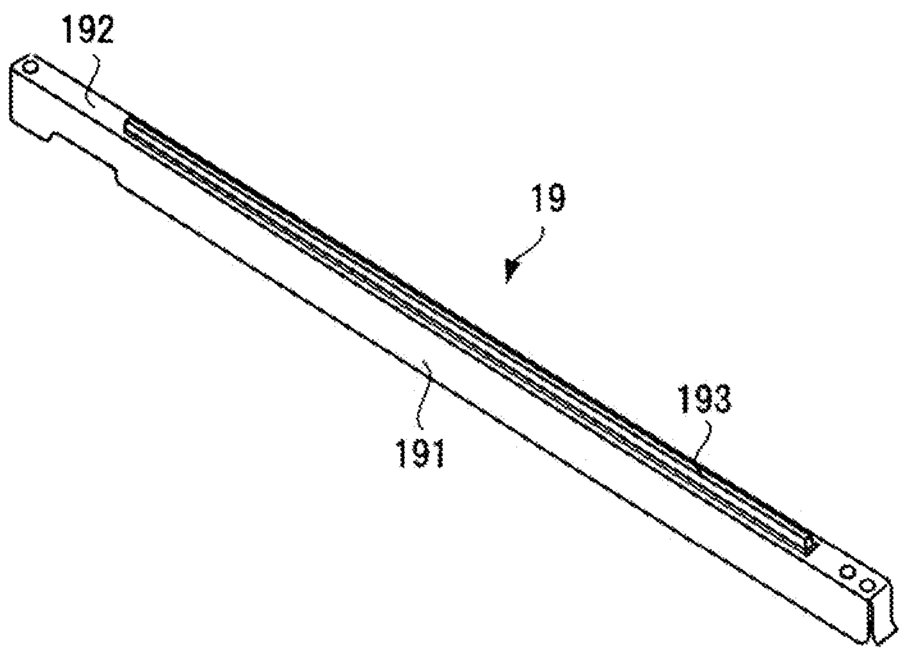


FIG. 4

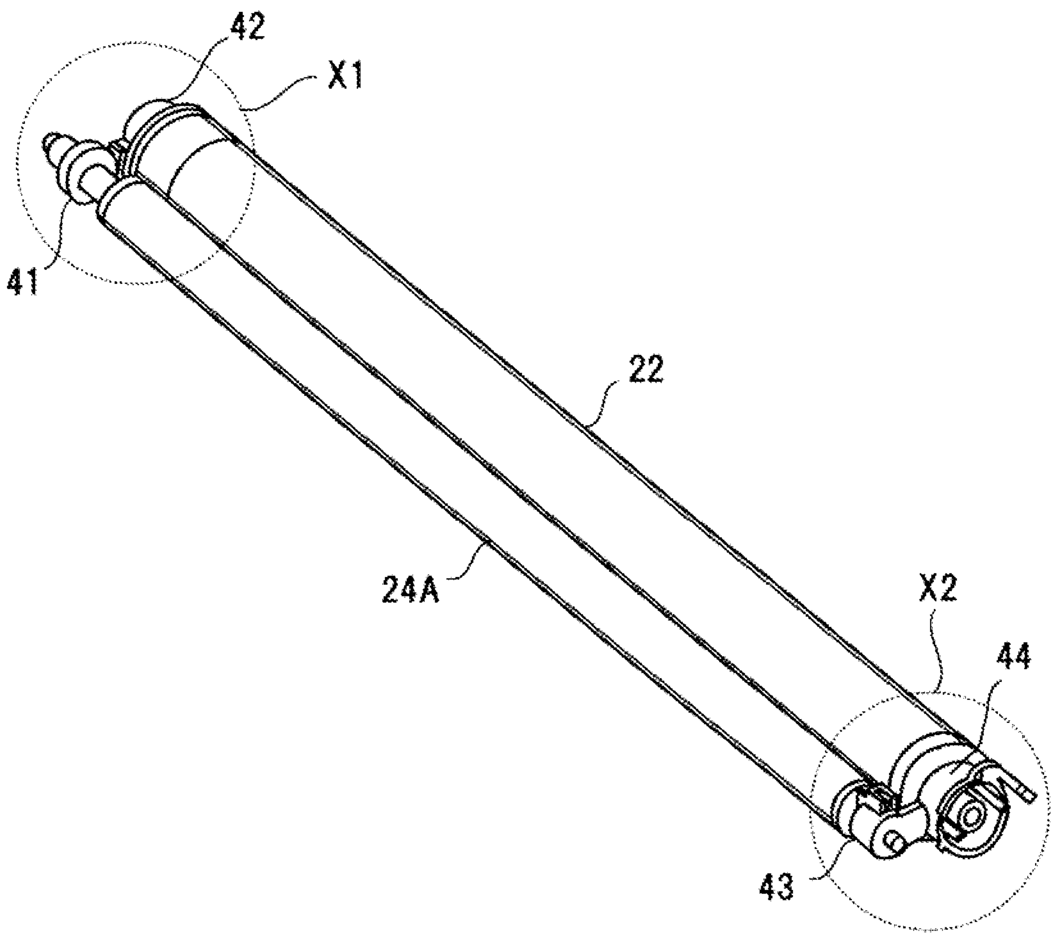


FIG. 5A

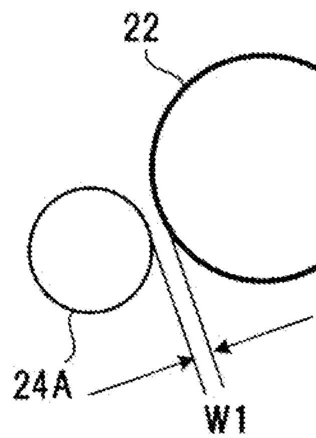


FIG. 5B

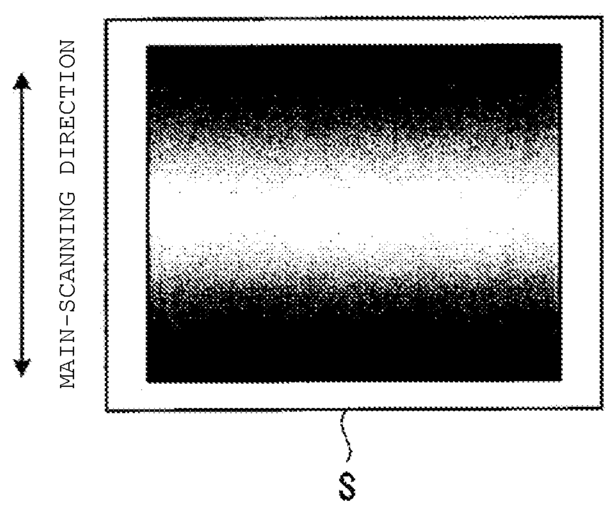


FIG. 6

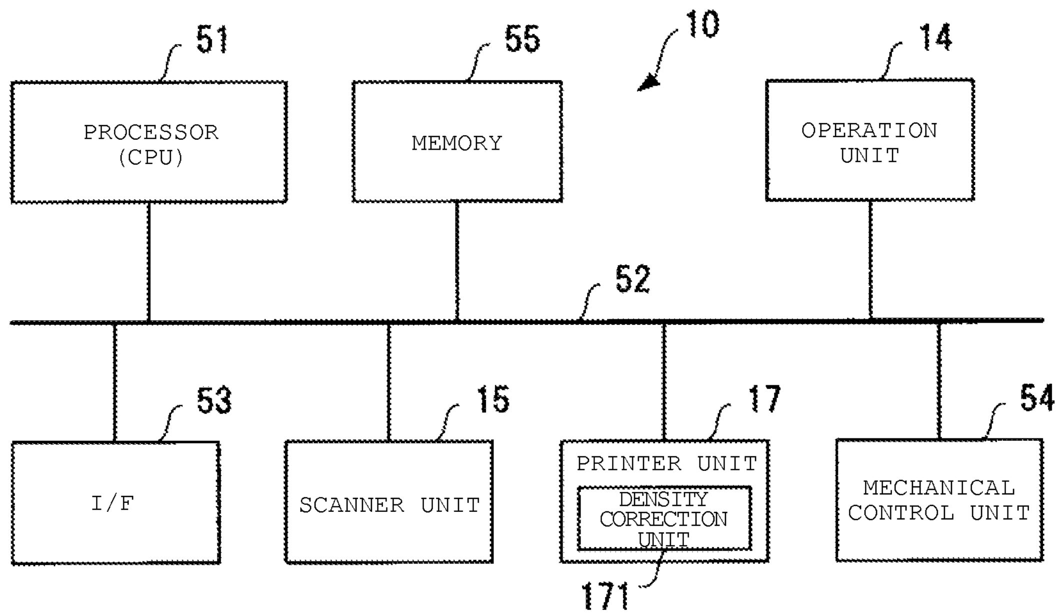

10
51
PROCESSOR (CPU)
55
MEMORY
14
OPERATION UNIT
52
53
I/F
15
SCANNER UNIT
17
PRINTER UNIT
DENSITY CORRECTION UNIT
171
54
MECHANICAL CONTROL UNIT

FIG. 7

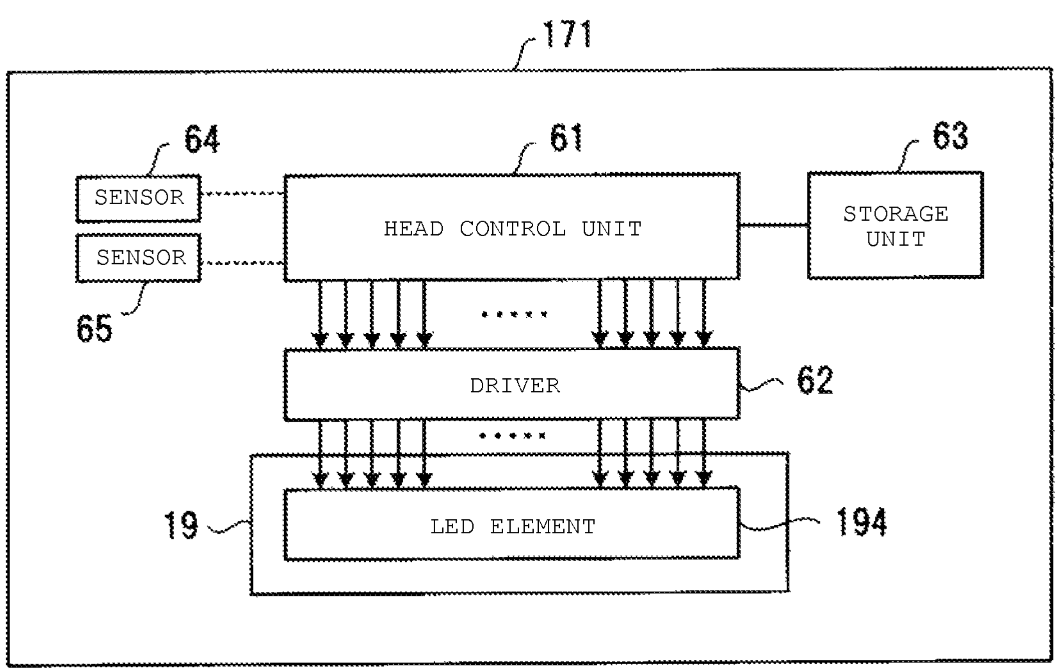

171
64
SENSOR
SENSOR
65
61
HEAD CONTROL UNIT
63
STORAGE UNIT
DRIVER
62
19
LED ELEMENT
194

FIG. 8

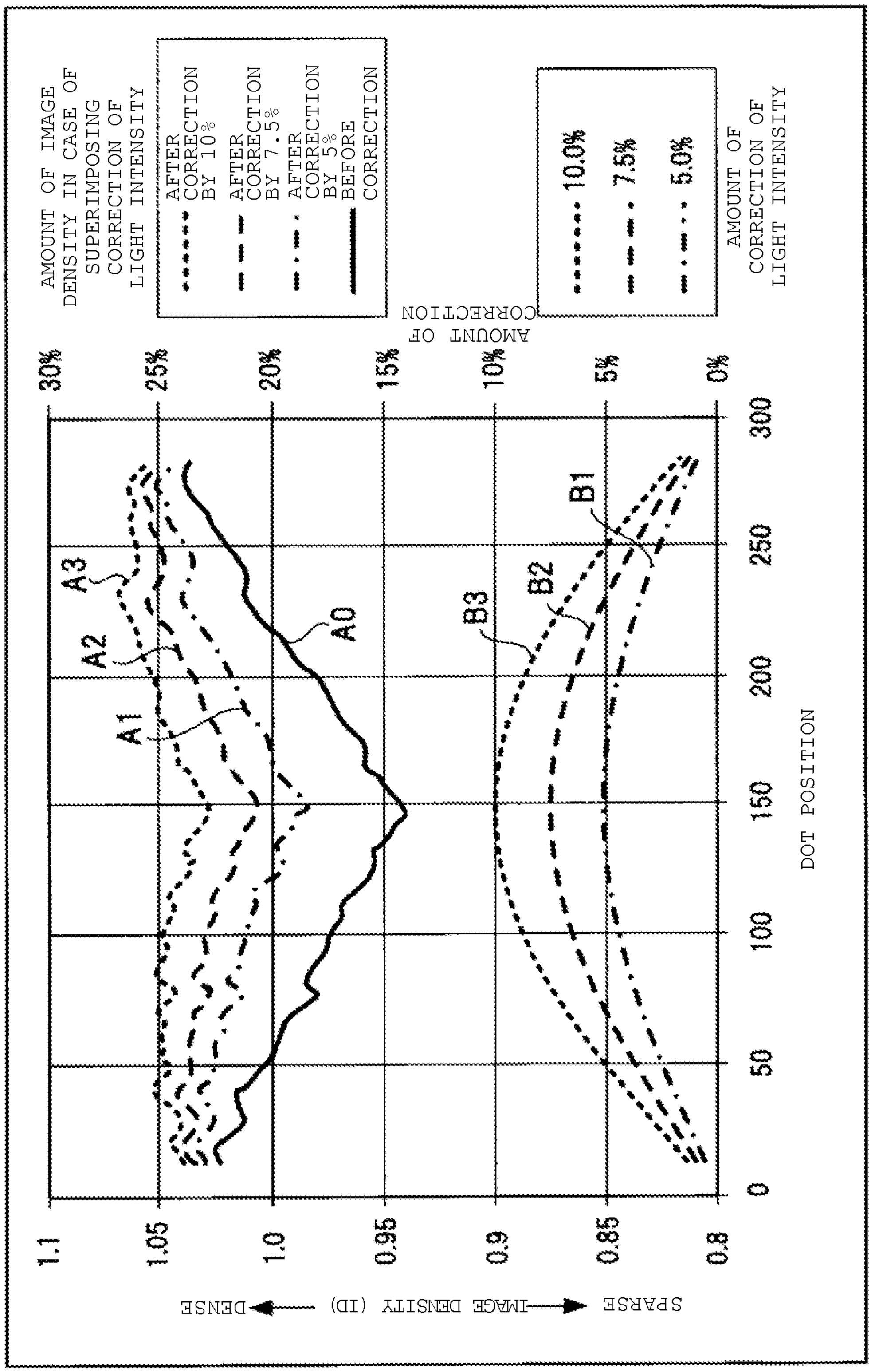

AMOUNT OF IMAGE DENSITY IN CASE OF SUPERIMPOSING CORRECTION OF LIGHT INTENSITY
AFTER CORRECTION BY 10%
AFTER CORRECTION BY 7.5%
AFTER CORRECTION BY 5%
BEFORE CORRECTION
AMOUNT OF CORRECTION
10.0%
7.5%
5.0%
AMOUNT OF CORRECTION OF LIGHT INTENSITY
30%
25%
20%
15%
10%
5%
0%
A0
A1
A2
A3
B1
B2
B3
1.1
1.05
1.0
0.95
0.9
0.85
0.8
0
50
100
150
200
250
300
DOT POSITION
SPARSE ← IMAGE DENSITY (ID) → DENSE

FIG. 9

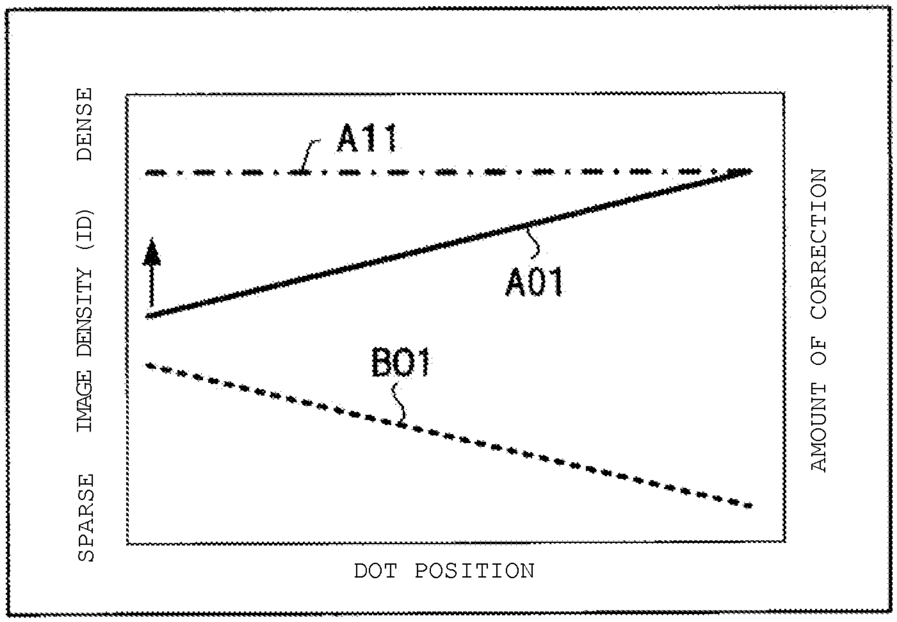

A11
A01
B01
SPARSE IMAGE DENSITY (ID) DENSE
AMOUNT OF CORRECTION
DOT POSITION

FIG. 10

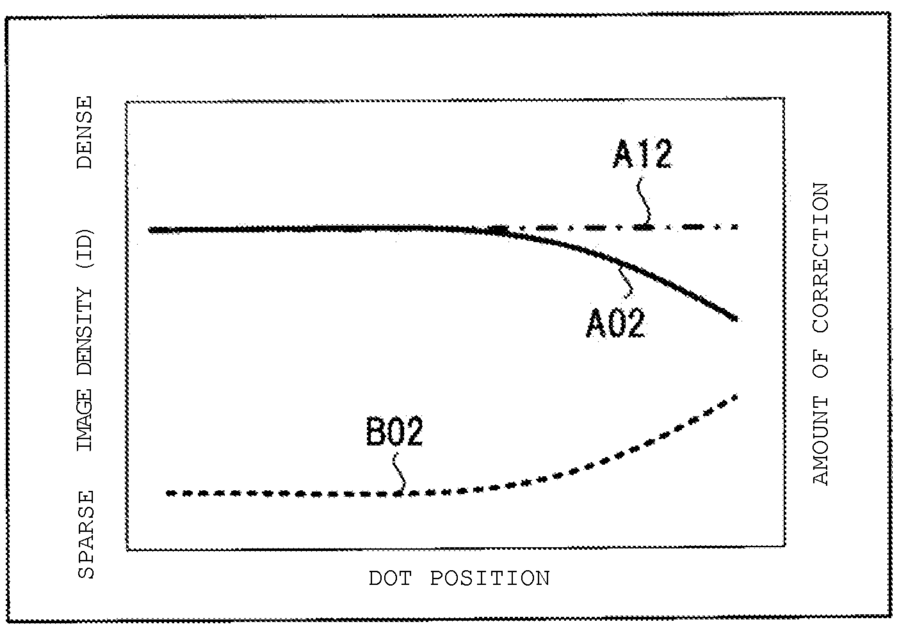

A12
A02
B02
SPARSE IMAGE DENSITY (ID) DENSE
AMOUNT OF CORRECTION
DOT POSITION

FIG. 11

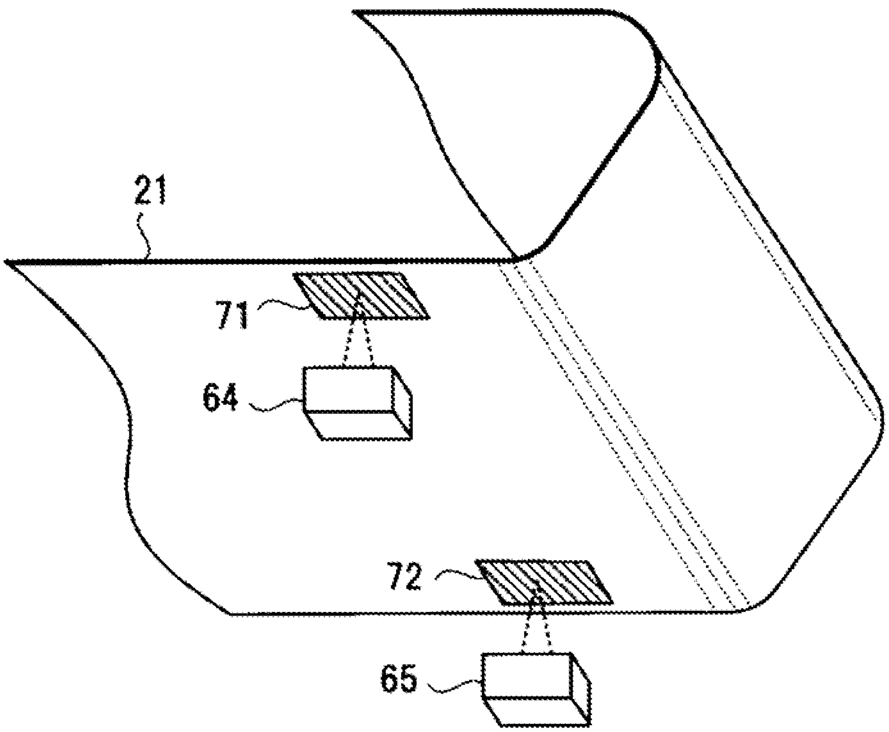


IMAGE FORMING APPARATUS AND EXPOSING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2014-006607, filed Jan. 17, 2014, the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to an image forming apparatus, such as an electrophotographic copy machine, and particularly to an image forming apparatus and an exposing apparatus that provide uniform density of an image by correcting the intensity of light of a light scan head (LED head) to compensate for non-uniform density of the image in a main-scanning direction.

BACKGROUND

An image forming apparatus of the related art may employ a light-emitting diode (LED) head. The LED head includes a plurality of LED elements disposed in a main-scanning direction of the LED head. A plurality of LED heads can be disposed in an image forming apparatus for recording images of cyan (C), magenta (M), yellow (Y), and black (K) colors.

When the image forming apparatus prints an image on a sheet, image density may be non-uniform in the main scanning direction, thus posing a problem of deteriorating image quality. The non-uniform image density in the main-scanning direction is mainly caused by variations in mechanical accuracy of the position of a photoreceptor drum and a development roller (e.g., magnetic roller). The variations cause an interval (gap) between the photoreceptor drum and the development roller to be different in the longitudinal direction of the photoreceptor drum and the development roller, thus widening the gap at a central part in the longitudinal direction. In addition, non-uniform image density can also be caused by the photoreceptor drum and the LED head being dislocated in the longitudinal direction.

A regulation member that faces the development roller and regulates the thickness of a layer of a developer is disposed at a predetermined interval with respect to the development roller. The regulation member regulates the layer of the developer on the outer surface of the development roller so that the developer layer does not become excessively thick. However, the image density becomes non-uniform when the development roller bends to decrease the amount of the developer that adheres to the central part of the development roller in the longitudinal direction. In addition, the regulation member bends to change the amount of the developer transported on the development roller, thus causing the non-uniform image density.

Techniques to compensate for the non-uniform image density include improving accuracy and rigidity of components in a part where the gap is formed between the photoreceptor drum and the development roller, or adjusting magnetic power of the development roller in the longitudinal direction. However, these techniques increase cost.

Another technique involves controlling the intensity of light emitted from the LED to correct the non-uniform image density. For example, an image is read, analyzed, and is computationally processed to give feedback to each LED element for correcting change in the intensity of light emitted from the LED element due to temperature change. However, such a technique increases circuit complexity and cost.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a configuration diagram illustrating an image forming apparatus according to a first embodiment.

FIG. **2** is a configuration diagram illustrating one enlarged image formation unit in the first embodiment.

FIG. **3** is a perspective diagram illustrating an LED head in the first embodiment.

FIG. **4** is a perspective diagram illustrating a photoreceptor drum and a development roller in the first embodiment.

FIGS. **5**A and **5**B are diagrams illustrating a gap between the photoreceptor drum and the development roller and non-uniform image density of an image due to change in the width of the gap in the first embodiment.

FIG. **6** is a systematic configuration diagram illustrating the image forming apparatus in the first embodiment.

FIG. **7** is a block diagram illustrating the configuration of a density correction unit in the first embodiment.

FIG. **8** is a characteristic diagram illustrating correction of the intensity of light of the LED element in the first embodiment.

FIG. **9** is another characteristic diagram illustrating correction of the intensity of light of the LED element in the first embodiment.

FIG. **10** is still another characteristic diagram illustrating correction of the intensity of light of the LED element in the first embodiment.

FIG. **11** is a configuration diagram illustrating the disposition of a sensor in a second embodiment.

DETAILED DESCRIPTION

Embodiments provide an image forming apparatus that controls the intensity of light emitted from each LED element to correct non-uniform image density in a main-scanning direction due to change in the amount of a developer adhered to a photoreceptor drum.

In general, according to one embodiment, there is provided an image forming apparatus including a light scan head that includes a plurality of LED elements which are disposed along a main-scanning direction of a photoreceptor drum and configured to expose the photoreceptor drum with light, a developing device that is disposed to face the photoreceptor drum in the main-scanning direction and includes a development roller configured to supply a developer to the photoreceptor drum, and a non-uniform density correction unit configured to control an intensity of the light emitted from the plurality of LED elements of the light scan head based on correction data that corresponds to a tendency pattern of an expected non-uniform image density of an image that is to be formed on a recording medium caused by change in an adhesion amount of the developer which is supplied to the photoreceptor drum from the developing device when transferring a toner image on the photoreceptor drum to the recording medium.

Hereinafter, exemplary embodiments will be described with reference to the accompanying drawings. The same place in each drawing will be given the same reference sign.

First Embodiment

FIG. **1** is a configuration diagram of an image forming apparatus according to a first embodiment. An image forming apparatus **10**, for example, is a multi-function peripheral

(MFP) that is a multi-function machine, a printer, a copy machine, or the like in FIG. **1**. An MFP will be exemplified in the following description.

A transparent glass document table **12** is in an upper portion of a main body **11** of the MFP **10**. An automatic document feeder (ADF) **13** is disposed to be opened and closed over the document table **12**. In addition, an operation panel **14** is disposed in the upper portion of the main body **11**. The operation panel **14** includes a touch panel-type display unit and various operation keys.

A scanner unit **15** that is a reading device is disposed under the ADF **13** inside the main body **11**. The scanner unit **15** reads a document that is transported by the ADF **13** or a document that is placed on the document table to generate image data and includes an image sensor **16**. The image sensor **16** is disposed in a main-scanning direction (depth direction in FIG. **1**.

When reading an image on a document placed on the document table **12**, the image sensor **16** reads the image on the document by one line while moving along the document table **12**. The image sensor **16** performs the above read operation along the entire size of the document to read one page of the document. When reading an image on a document transported by the ADF **13**, the image sensor **16** is fixed at a position (the position illustrated in FIG. **1**.).

A printer unit **17** is provided in a central portion of the main body **11**, and a plurality of cassettes **18** that accommodate sheets of various sizes are provided in a lower portion of the main body **11**. The printer unit **17** includes a photoreceptor drum and a light scan head that is disposed along the main-scanning direction of the photoreceptor drum. The light scan head includes a plurality of LED elements that are light-emitting elements. The light scan head scans and exposes the photoreceptor drum with rays of light from each LED element.

The printer unit **17** processes image data read in the scanner unit **15** or image data created in a personal computer (PC) and the like to form an image on a sheet that is a recording medium. The printer unit **17**, for example, is a color laser printer that uses a tandem system and includes image formation units **20**Y, **20**M, **20**C, and **20**K respectively corresponding to yellow (Y), magenta (M), cyan (C), and black (K) colors.

The image formation units **20**Y, **20**M, **20**C, and **20**K are disposed parallel to each other on the lower side of an intermediate transfer belt **21** from the upstream side to the downstream side. In addition, a light scan head **19** includes a plurality of light scan heads **19**Y, **19**M, **19**C, and **19**K corresponding to the image formation units **20**Y, **20**M, **20**C, and **20**K.

FIG. **2** is a configuration diagram illustrating one of the enlarged image formation units **20**Y, **20**M, **20**C, and **20**K. Each of the image formation units **20**Y, **20**M, **20**C, and **20**K has the same configuration and thus will be described as an image formation unit **20** without the reference signs K, M, C, and K.

An electrifying charger **23**, a developing device **24**, a primary transfer roller **25**, a cleaner **26**, a blade **27**, and the like are disposed around the photoreceptor drum **22** along a direction of rotation t. An exposed position on the photoreceptor drum **22** is illuminated with light from the light scan head **19**, and a latent image is formed on the photoreceptor drum **22**.

The electrifying charger **23** uniformly electrifies the entire outer surface of the photoreceptor drum **22** at substantially −700 V, for example. The developing device **24** supplies a two-component developer formed of a toner and a carrier for each color to the photoreceptor drum **22** using a development roller **24**A to which a development bias of substantially −500 V is applied, and develops the latent image on the photoreceptor drum **22** to form a toner image on the photoreceptor drum **22**. The development roller **24**A includes a plurality of fixed magnets and a sleeve that is supported to be rotatable around the outer circumference of the magnets and is also referred to as a magnet roller. The cleaner **26** uses the blade **27** to remove a toner that remains on the outer surface of the photoreceptor drum **22**.

A regulation member **29** that regulates the thickness of a layer of the developer is disposed to face the development roller **24**A. The regulation member **29** extends parallel to the direction of the axis of the development roller **24**A and is disposed at a predetermined interval with respect to the outer surface of the development roller **24**A. The regulation member **29** regulates the layer of the developer on the outer surface of the development roller **24**A to prevent the layer of developer from becoming excessively thick.

As illustrated in FIG. **1**, a toner cartridge **28** is disposed above the image formation units **20**Y to **20**K to supply a toner to the developing device **24**. The toner cartridge **28** includes toner cartridges (**28**Y to **28**K) of respective yellow (Y), magenta (M), cyan (C), and black (K) colors.

The intermediate transfer belt **21** is stretched over a drive roller **31** and a passive roller **32** and moves in a circulating manner. In addition, the intermediate transfer belt **21** is facing and in contact with photoreceptor drums **22**Y to **22**K. A primary transfer voltage is applied to a position of the intermediate transfer belt **21** that faces the photoreceptor drum **22** by the primary transfer roller **25**, and the toner image on the photoreceptor drum **22** is primarily transferred to the intermediate transfer belt **21**.

A secondary transfer roller **33** is disposed to face the drive roller **31** that stretches the intermediate transfer belt **21**. A secondary transfer voltage is applied to a sheet S by the secondary transfer roller **33** when the sheet S passes between the drive roller **31** and the secondary transfer roller **33**. Then, the toner image on the intermediate transfer belt **21** is secondarily transferred to the sheet S. A belt cleaner **34** is disposed in the vicinity of the passive roller **32** and the intermediate transfer belt **21**.

A transport roller **35** is disposed between the cassette **18** and the secondary transfer roller **33** to transport the sheet S that is drawn out of the cassette **18** as illustrated in FIG. **1**. A fixing device **36** is disposed downstream of the secondary transfer roller **33**. A transport roller **37** is disposed downstream of the fixing device **36**. The transport roller **37** discharges the sheet S to a sheet discharge unit **38**. An inversion transport path **39** is disposed downstream of the fixing device **36**. The inversion transport path **39** inverts the sheet S to guide the sheet S to the secondary transfer roller **33** and is used when performing a duplex printing.

FIG. **3** is a perspective diagram illustrating the LED head **19** that is the light scan head. The LED head **19** includes a main body **191** and a cover **192** that covers the main body **191**. A light condenser lens array **193** is disposed on the cover **192**. A plurality of LED elements **194** (FIG. **7**) that are recording elements are disposed linearly along the main-scanning direction in the main body **191**. Light emitted from each LED element **194** is condensed in the light condenser lens array **193** and is emitted therefrom. The LED head **19** is provided for each of yellow (Y), magenta (M), cyan (C), and black (K) colors (denoted by **19**Y, **19**M, **19**C, and **19**K) in the MFP **10**.

Without compensation, image density can become non-uniform in the main-scanning direction when the printer unit **17** prints an image on the sheet S. The non-uniform image density in the main-scanning direction is caused by variations in mechanical accuracy of the position of the photoreceptor drum **22** and the development roller **24**A. The variations cause an interval (gap) between the photoreceptor drum **22** and the development roller **24**A to vary along the longitudinal direction of the photoreceptor drum **22** and the development roller **24**A, thus widening the gap, for example, at a central portion in the longitudinal direction.

FIG. **4** is a perspective diagram illustrating the photoreceptor drum **22** and the development roller **24**A. The photoreceptor drum **22** and the development roller **24**A face each other and extend parallel to the main-scanning direction as illustrated in FIG. **4**. Regarding one end portion X**1**, a bearing **41** is provided at one end of the development roller **24**A and is pressed to the side of the photoreceptor drum **22**. One end portion of the photoreceptor drum **22** that faces the bearing **41** includes a molded component **42**.

Regarding the other end portion X**2**, a molded component **43** is provided at the other end of the development roller **24**A and is pressed to the side of the photoreceptor drum **22**. The other end portion of the photoreceptor drum **22** that faces the molded component **43** includes a molded component **44**.

FIG. **5**A is a diagram illustrating the gap between the photoreceptor drum **22** and the development roller **24**A. A gap width W**1** is originally designed to be constant. The gap width may become non-constant as a result of the components in one end portion X**1** and the other end portion X**2** that form the gap being different from each other. For example, the gap width can be 40 μm in one end portion X**1** and can be 35 μm in the other end portion X**2**. In addition, the gap width between the photoreceptor drum and the development roller tends to be widened at the central part between both end portions in the longitudinal direction (main-scanning direction).

Image density becomes non-uniform as illustrated in FIG. **5**B when the gap is widened in the central portion in the main-scanning direction, causing the amount of the developer that adheres to the photoreceptor drum **22** to be decreased in the central portion. FIG. **5**B illustrates a slightly exaggerated example of non-uniform image density when printing an image of a middle tone (gray color) on the entire sheet S. Density in the central portion is decreased (e.g., the image becomes lighter) when the gap width is widened in the central portion in the main-scanning direction.

The non-uniformity of the image density may change depending on variation in the gap width. For example, density may be sparse in one end portion and dense in the other portion in the main-scanning direction, or conversely, density may be dense in one end portion and sparse in the other portion in the main-scanning direction.

In addition, image density may be non-uniform due to change in the amount of the developer transported on the development roller **24**A as the developer bends though the regulation member **29** that is disposed to face the development roller **24**A to regulate the thickness of the layer of the developer, as illustrated in FIG. **2**.

In an embodiment, the non-uniform image density is corrected by adjusting the intensity of light emitted from the LED element of the LED head **19**. That is, the gap width W**1** that is a cause of the non-uniform image density is substantially stabilized depending on accuracy and rigidity of components (bending of the development roller **24**A and the like). Accordingly, tendencies of the non-uniform image density (tendency patterns) can be determined for each product. Thus, the intensity of light and a drive time of LEDs are corrected prior to factory shipping to correct difference in the density of an image, thereby correcting non-uniform image density of an image.

Hereinafter, correction of non-uniform image density will be described. FIG. **6** is a systematic configuration diagram illustrating the image forming apparatus **10** (for example, the MFP) that uses the LED head **19**. The MFP **10** includes a processor **51** that is a control unit. The processor **51** is connected to a communication interface (I/F) **53**, the scanner unit **15**, the printer unit **17**, a mechanical control unit **54** that controls a mechanical mechanism unit, the operation unit **14** that includes a display unit, a memory **55**, and the like through a bus line **52**.

The processor **51** is a computer that includes a CPU, performs predetermined processes based on an image process program stored in the memory **55**, and controls operations related to image formation. The memory **55**, for example, includes a random access memory (RAM), a read-only memory (ROM), a dynamic random access memory (DRAM), a static random access memory (SRAM), a video RAM (VRAM), or the like. Various information and programs used in the MFP **10** are stored in the memory **55**.

The communication interface (I/F) **53** communicates with external devices, such as a personal computer (PC) and the like. The operation unit **14**, for example, includes a touch panel-type display unit and various operation keys. A user or a serviceman may input various instructions in the operation unit **14**. The scanner unit **15** reads a document that is transported by the ADF **13** or a document that is placed on the document table to generate image data. The printer unit **17** forms an image on the sheet S and includes the image formation units (**20**Y, **20**M, **20**C, and **20**K) and the LED heads (**19**Y, **19**M, **19**C, and **19**K) described above. The printer unit **17** further includes a density correction unit **171**.

FIG. **7** is a block diagram illustrating the configuration of the density correction unit **171**. The density correction unit **171** includes a head control unit **61** that controls the LED head **19**, a driver **62** that drives each LED element **194** of the LED head **19**, and a storage unit **63**. The LED elements **194** are aligned along the main-scanning direction and are disposed to correspond to each pixel when forming an image.

The head control unit **61** supplies a drive signal that corresponds to the image data to the driver **62**. The driver **62** supplies a current for each pixel to the corresponding LED element **194**. The current (intensity of emitted light) to the LED element **194** is adjusted by the drive signal supplied to the driver **62** from the head control unit **61**. Thus, the intensity of light with which the photoreceptor drum **22** is exposed may be changed.

Correction data for correcting the intensity of light emitted from the LED element **194** is stored in the storage unit **63**. For example, correction data for increasing the intensity of light of the LED element in the central portion of the LED element **194** in the main-scanning direction is stored in the storage unit **63** for a tendency pattern in which the gap width between the development roller **24**A and the photoreceptor drum **22** is widened in the central portion in the main-scanning direction, and image density becomes sparse in the central portion of the sheet S in the main-scanning direction as illustrated in FIG. **5**B. In other examples, correction data can be stored for other tendency patterns having non-uniform image density in various forms when forming an image on the sheet S.

The head control unit **61** reads correction data from the storage unit **63** and supplies a correction signal for correcting density to the driver **62** when supplying a current for each pixel to the LED element **194**. Besides changing a current that flows in the LED element, a drive time of the LED element may be changed to adjust the intensity of light emitted from the LED element **194**.

FIG. **8** is a characteristic diagram illustrating correction of the intensity of light of the LED element. That is, FIG. **8** is a diagram illustrating an example of the amount of correction of image density and the intensity of light of the LED element by the density correction unit **171**. The vertical axis (left) in FIG. **8** illustrates image density, and the vertical axis (right) illustrates the amount of correction (%). The horizontal axis illustrates a dot position of the LED element **194** in the main-scanning direction.

A characteristic graph A**0** in an upper portion of FIG. **8** illustrates non-uniform image density in which the gap width between the development roller **24**A and the photoreceptor drum **22** is widened in the central portion in the main-scanning direction, and image density becomes sparse in the central portion of the sheet S in the main-scanning direction.

Characteristic graphs B**1** to B**3** in a lower portion of FIG. **8** illustrate correction data for the non-uniform image density A**0**. For example, the correction data B**1** illustrates an example in which the intensity of light emitted from the LED element that corresponds to the dot position at the central part is corrected (increased) by 5%, and the intensity of light emitted from the LED element that corresponds to the dot position in the end portion is barely corrected.

When the non-uniform image density is corrected based on the correction data B**1**, image density in the central portion in the main-scanning direction in the characteristic graph A**0** becomes slightly more dense, as illustrated in a characteristic graph A**1**. The correction data B**2** is for correcting (increasing) the intensity of light emitted from the LED element by 7.5%. When the non-uniform image density is corrected based on the correction data B**2**, image density in the central portion in the main-scanning direction becomes still more dense, as illustrated in a characteristic graph A**2**. The correction data B**3** is for correcting (increasing) the intensity of light emitted from the LED element by 10%. When the non-uniform image density is corrected based on the correction data B**3**, image density in the central portion in the main-scanning direction becomes still more dense as illustrated in a characteristic graph A**3**.

That is, the density correction unit **171** controls the intensity of light emitted from the plurality of LED elements **194** of the LED head **19** based on the correction data with respect to characteristics and reverse characteristics of the non-uniform image density. Accordingly, reading correction data that corresponds to a tendency pattern of non-uniform image density from the storage unit **63** and correcting the intensity of light emitted from the LED element **194** based on the correction data may correct image density of an image to be printed. Non-uniform image density may be corrected by allowing a user to finely adjust the amount of correction when it is difficult to sufficiently correct the non-uniform image density with correction data.

FIG. **9** is a characteristic diagram illustrating correction of the intensity of light of the LED element and illustrates another tendency pattern. A characteristic graph A**01** in an upper portion of FIG. **9** illustrates an example in which image density becomes dense linearly from one end portion to the other end portion in the main-scanning direction. Correction data B**01** in FIG. **9** is used for the tendency pattern A**01**. With the correction data B**01**, correction is made in such a manner that the intensity of light emitted from the LED element that corresponds to the dot position in one end portion in the main-scanning direction is increased, and the intensity of light emitted from the LED element **194** that corresponds to the dot position in the other end portion is decreased. Accordingly, the non-uniform image density may be corrected as illustrated in a characteristic graph A**11**.

FIG. **10** is a characteristic diagram illustrating correction of the intensity of light of the LED element and illustrates still another tendency pattern. A characteristic graph A**02** in an upper portion of FIG. **10** illustrates an example in which image density is substantially uniform from one end portion to the central portion in the main-scanning direction but becomes sparse from the central portion to the other end portion. Correction data B**02** in FIG. **10** is used for the tendency pattern A**02**. With the correction data B**02**, correction is made in such a manner that the intensity of light emitted from the LED element that corresponds to the dot position from one end portion to the central portion in the main-scanning direction is constant, and the intensity of light emitted from the LED element **194** that corresponds to the dot position from the central portion to the other end portion is gradually increased. Accordingly, the non-uniform image density may be corrected as illustrated in a characteristic graph A**12**.

When the intensity of light or a characteristic of light emission of the individual LED element **194** varies in recording an image using the LED head **19**, image density may be non-uniform, or irregular streaking may occur, in a direction orthogonal to the direction in which the LED head **19** is aligned (main-scanning direction). For this reason, generally, the intensity of light emitted from each LED element is individually detected, and a corresponding duty cycle of light emitted from the LED element is changed according to each detected value to correct the intensity of emitted light. In this case, the head control unit **61** superimposes correction data for correcting non-uniform image density caused by change in the amount of the transported developer described above on correction data for correcting variations in the individual LED element to control the intensity of light emitted from each LED element.

In the embodiment described above, the intensity of light emitted from the LED element may be corrected based on correction data for tendency patterns, and thus, non-uniform image density may be corrected even when image density becomes non-uniform in the main-scanning direction because of the amount of the developer that adheres to the photoreceptor drum **22** being changed due to the gap width between the photoreceptor drum **22** and the development roller **24**A or due to bending of the development roller **24**A or the regulation member **29**.

Second Embodiment

FIG. **11** is a configuration diagram related to a second embodiment. In the second embodiment, inspection images **71** and **72** for correction are printed on both sides (the front side and the rear side) of the transfer belt **21**. The inspection images **71** and **72** are respectively detected by sensors **64** and **65**, and the detection result is supplied to the head control unit **61**. The inspection images **71** and **72** are printed outside an image formation area of the sheet S (on an end portion of the belt). As the sensors **64** and **65**, for example, CCD sensors or CMOS sensors used in digital cameras are used.

Image densities of the inspection images **71** and **72** printed on the transfer belt **21**, for example, differ from each other in the case of the tendency pattern A**01** illustrated in FIG. **9**. The sensors **64** and **65** detect the inspection images **71** and **72** and supply the detection result to the head control unit **61**. The head control unit **61** calculates the difference of the image densities from the detection result of the sensors **64** and **65** and drives the LED element **194** so that the densities of the inspection images **71** and **72** are substantially equalized.

For example, in the case of the tendency pattern A**01** illustrated in FIG. **9**, since the image densities detected by each of the sensors **64** and **65** differ from each other, correction is made in such a manner that the intensity of light emitted from the LED element that corresponds to the dot position in one end portion (left) in the main-scanning direction is increased by an amount of the difference thereof from the intensity of light emitted from the LED element **194** that corresponds to the dot position in the other end portion (right), and the intensity of light emitted from the LED element **194** in the central portion is increased by half the amount of the difference. Accordingly, the non-uniform image density may be corrected as illustrated in the characteristic graph **A11**.

According to the second embodiment, non-uniform image density on the front side and the rear side of the transfer belt **21** may be corrected by detecting the inspection images **71** and **72** with the sensors **64** and **65** installed on the front side and the rear side of the transfer belt **21** even when tendency patterns are changed due to variations in components or an installed state of the MFP **10**.

According to the embodiments described above, non-uniform image density may be corrected by correcting the intensity of light emitted from the LED element even when image density becomes non-uniform in the main-scanning direction. Such non-uniformity in image density can result when the amount of the transported developer varies due to variations in the gap between the photoreceptor drum **22** and the development roller **24**A or the regulation member **29** in addition to variations in the characteristic of light emission of the LED element.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. An image forming apparatus, comprising:

a light scan head including a plurality of LED elements, disposed along a main-scanning direction of a photoreceptor drum, configured to expose the photoreceptor drum with light;

a developing device, disposed to face the photoreceptor drum in the main-scanning direction, including a development roller configured to supply a developer to the photoreceptor drum;

a transfer belt configured to transfer the toner image on the photoreceptor drum to a recording medium; and

a non-uniform density correction unit configured to control an intensity of the light emitted from the plurality of LED elements of the light scan head based on correction data, the correction data corresponding to a tendency pattern of an expected non-uniform image density of an image that is to be formed on the recording medium caused by change in an adhesion amount of the developer which is supplied to the photoreceptor drum from the developing device when transferring a toner image on the photoreceptor drum to the recording medium, the non-uniform density correction unit including:

first and second sensors configured to respectively detect a first inspection image and a second inspection image that are printed on both sides of the transfer belt outside an image formation area of the transfer belt; and

a control unit configured to calculate a difference in image densities of the first and second inspection images as detected by the first and second sensors, and control the intensity of light emitted from the plurality of LED elements based on the difference in the image densities.

2. The apparatus according to claim **1**,

wherein the non-uniform density correction unit stores correction data that corresponds to a plurality of tendency patterns of non-uniform image density of an image formed on a recording medium in a storage unit, and controls intensity of light emitted from the plurality of LED elements based on the correction data that is read from the storage unit.

3. The apparatus according to claim **1**,

wherein the control unit is configured to control the intensity of light emitted from the plurality of LED elements to substantially equalize the difference in the image densities of the first and second inspection images.

4. The apparatus according to claim **1**,

wherein the non-uniform image density of the image formed on the recording medium comprises effects of a variation in a gap width between the photoreceptor drum and the development roller along the main-scanning direction.

5. The apparatus of claim **4**, wherein the gap width is wider in a central portion along the main-scanning direction than in respective end portions.

6. An exposing apparatus for an image forming apparatus having a developing device disposed to face a photoreceptor drum in a main-scanning direction, the developing device including a development roller configured to supply a developer to the photoreceptor drum, the exposing apparatus, comprising:

a plurality of LED elements which are disposed along the main-scanning direction of the photoreceptor drum and configured to expose the photoreceptor drum with light;

a transfer belt configured to transfer the toner image on the photoreceptor drum to a recording medium; and

a non-uniform density correction unit configured to control intensity of the light emitted from the plurality of LED elements based on correction data, the correction data corresponding to a tendency pattern of an expected non-uniform image density of an image that is to be formed on a recording medium caused by change in an adhesion amount of the developer which is supplied to the photoreceptor drum from the developing device when transferring a toner image on the photoreceptor drum to the recording medium, the non-uniform density correction unit including:

first and second sensors configured to respectively detect a first inspection image and a second inspection image that are printed on both sides of the transfer belt outside an image formation area of the transfer belt; and

a control unit configured to calculate a difference in image densities of the first and second inspection images as detected by the first and second sensors, and control the intensity of light emitted from the plurality of LED elements based on the difference in the image densities.

7. The apparatus according to claim **6**,

wherein the non-uniform density correction unit stores correction data that corresponds to a plurality of tendency patterns of non-uniform image density of an image formed on a recording medium in a storage unit, and controls intensity of light emitted from the plurality of LED elements based on the correction data that is read from the storage unit.

8. The apparatus according to claim **6**,

wherein the control unit is configured to control the intensity of light emitted from the plurality of LED elements to substantially equalize the difference in the image densities of the first and second inspection images.

9. The apparatus according to claim **6**,

wherein the non-uniform image density of the image formed on the recording medium comprises effects of a variation in a gap width between the photoreceptor drum and the development roller along the main-scanning direction.

10. The apparatus of claim **9**, wherein the gap width is wider in a central portion along the main-scanning direction than in respective end portions.

11. A method of operating an image forming apparatus having a developing device disposed to face a photoreceptor drum in a main-scanning direction, the developing device including a development roller configured to supply a developer to the photoreceptor drum, the image forming apparatus further comprising a transfer belt configured to transfer the toner image on the photoreceptor drum to the recording medium, the method comprising:

exposing the photoreceptor drum with light generated by a plurality of LED elements;

controlling the intensity of the light emitted by the plurality of LED elements based on correction data, the correction data corresponding to a tendency pattern of an expected non-uniform image density of an image that is to be formed on a recording medium caused by change in an adhesion amount of the developer which is supplied to the photoreceptor drum from the developing device when transferring a toner image on the photoreceptor drum to the recording medium;

detecting a first inspection image and a second inspective image printed on both sides of the transfer belt outside an image formation area of the transfer belt;

calculating a difference in image densities of the first and second inspection images; and

controlling the intensity of the light emitted by the plurality of LED elements to substantially equalize the difference in the image densities.

12. The method of claim **11**, wherein a plurality of correction data each corresponding to one of a plurality of tendency patterns of non-uniform image density of an image formed on a recording medium are stored, and the intensity of light emitted from the plurality of LED elements is controlled based on one of the stored correction data.

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